ENERGY STAR® Portfolio Manager®

Technical Reference

ENERGY STAR Score for Medical Offices in the United States

OVERVIEW

The ENERGY STAR Score for Medical Offices applies to facility space used to provide diagnosis and treatment for medical, dental, or psychiatric outpatient care. The objective of the ENERGY STAR score is to provide a fair assessment of the energy performance of a property relative to its peers, considering the climate, weather, and business activities at the property. To identify the aspects of building activity that are significant drivers of energy use and then normalize for those factors, a statistical analysis of the peer building population is performed. The result of this analysis is an equation that will predict the energy use of a property, based on its experienced business activities. The energy use prediction for a building is compared to its actual energy use to yield a 1 to 100 percentile ranking of performance, relative to the national population.

- Property Types. The ENERGY STAR score for medical offices applies to facility space used to provide diagnosis and treatment for medical, dental, or psychiatric outpatient care. The score applies to individual buildings only and is not available for campuses.
- Reference Data. The analysis for medical offices is based on data from an industry survey conducted by the America Society for Healthcare Engineering (ASHE), a personal membership society of the American Hospital Association (AHA), for the 2015 calendar year.
- Adjustments for Weather and Business Activity. The analysis includes adjustments for:
    - Gross Floor Area
    - Hours of Operation per Week
    - Number of Workers on Main Shift
    - Number of MRI Machines
    - Number of Surgical Operating Beds
    - Weather and Climate (using Heating and Cooling Degree Days, retrieved based on ZIP code)

- Release Date. The ENERGY STAR score for medical offices is updated periodically as more recent data becomes available:
    - Most Recent Update: February 2022
    - Original Release: February 2004

This document presents details on the development of the 1 - 100 ENERGY STAR score for medical offices. More information on the overall approach to develop ENERGY STAR scores is covered in our Technical Reference for the ENERGY STAR Score, available at www.energystar.gov/ENERGYSTARScore. The subsequent sections of this document offer specific details on the development of the ENERGY STAR score for medical offices:

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REFERENCE DATA & FILTERS

For the ENERGY STAR score for medical offices, the reference data used to establish the peer building population in the United States is based on data from an industry survey conducted by the American Society for Healthcare Engineering (ASHE), a personal membership society of the American Hospital Association (AHA). EPA relies on publicly available external data sets to develop ENERGY STAR scores where feasible, but a sufficiently robust set of medical office building energy consumption information was not available.

The ASHE industry survey was designed to account for the variation in service found in medical office facilities. The 1999 Commercial Building Energy Consumption Survey (CBECS) was used to develop the previous model; however, it was determined that CBECS did not provide a sufficient set of variables for Medical Offices. The most recent survey collected data for the 2015 calendar year and provided more current and complete information on the industry. The survey was open to all interested participants, including non-members, and efforts were made by EPA, ASHE, and AHA to provide as large, diverse, and representative of a sample as possible.

To analyze the building energy and operating characteristics in this survey data, four types of filters are applied to define the peer group for comparison and to overcome any technical limitations in the data: Building Type Filters, Program Filters, Data Limitation Filters, and Analytical Filters. A complete description of each of these categories is provided in our Technical Reference for the ENERGY STAR Score, at www.energystar.gov/ENERGYSTARScore. *Figure 1* presents a summary of each filter applied in the development of the ENERGY STAR score for medical offices, the rationale behind the filter, and the resulting number of properties in the data set after the filter is applied. After all filters are applied, the remaining data set has 137 properties.

Figure 1 – Summary of Filters for the ENERGY STAR Score for Medical offices

Condition for Including an Observation in the Analysis	Rationale	Number Remaining
Must have complete data for energy use and operating characteristics.	EPA Program Filter – Complete data is necessary for analysis.	153
Must have Source EUI[1] greater than or equal to 100 kBtu/ft^2 and less than or equal to 600 kBtu/ft^2	Analytical Filter – Values determined to be data entry errors or statistical outliers.	143
Must have less than or equal to 5 workers per 1,000 square feet	Analytical Filter – Values determined to be data entry errors or statistical outliers.	141

[1] Source EUI refers to the EUI after parking and pool energy estimates have been removed to isolate the EUI for the Medical Office space.

Condition for Including an Observation in the Analysis	Rationale	Number Remaining
Must have less than or equal to 0.04 MRI Machines per 1,000 square feet	Analytical Filter – Values determined to be data entry errors or statistical outliers.	138
Must have floor area greater than or equal to 5,000 square feet	Analytical Filter – Analysis could not model behavior for buildings smaller than 5,000 ft^2.	137

Of the filters applied to the reference data, some result in constraints on calculating a score in Portfolio Manager and others do not. Building Type and Program Filters are used to limit the reference data to include only properties that are eligible to receive a score in Portfolio Manager and are therefore related to eligibility requirements. In contrast, Data Limitation Filters account for limitations in the data availability, but do not apply in Portfolio Manager. Analytical Filters are used to eliminate outlier data points or different subsets of data and may or may not affect eligibility. In some cases, a subset of the data will have different behavior from the rest of the properties (e.g., hotels smaller than 5,000 ft^2 do not behave the same way as larger buildings), in which case an Analytical Filter will be used to determine eligibility in Portfolio Manager. In other cases, Analytical Filters exclude a small number of outliers with extreme values that skew the analysis, but do not affect eligibility requirements. A full description of the criteria you must meet to get a score in Portfolio Manager is available at www.energystar.gov/EligibilityCriteria.

Related to the filters and eligibility criteria described above, another consideration is how Portfolio Manager treats properties that are situated on a campus. The main unit for benchmarking in Portfolio Manager is the property, which may be used to describe either a single building or a campus of buildings. The applicability of the ENERGY STAR score depends on the type of property. For medical office properties, the score is based on individual buildings, because the primary function of the medical office is contained within a single building and because the properties included in the reference data are single buildings. In cases where multiple offices are situated together (e.g., a medical office park), each individual building can receive its own ENERGY STAR score, but the campus cannot earn a score.

Survey Weights

Analysis of the medical office survey data showed that the survey included many facilities from certain regions of the country, particularly from the West and South. Therefore, rather than being a complete random sample of the population, the survey can be viewed as a stratified random sample, with multiple categories of respondents. In order to properly account for this stratification, survey sample weights were constructed to reflect the probability of being selected within each group. Observations were weighted by Census Bureau Region. Within each group, the weight of an individual observation was computed as:

Observation Weight = Total Size of Population in Group / Number of Responses in Group

The Total Size of Population in Group was obtained through geographical market data from the CBECS medical office data. The Number of Responses in Group was counted from the complete set of 153 medical offices in the survey.

VARIABLES ANALYZED

To normalize for differences in business activity, we perform a statistical analysis to understand what aspects of building activity are significant with respect to energy use. The filtered reference data set described in the previous section is analyzed using a weighted ordinary least squares regression, which evaluates energy use relative to business activity (e.g., number of workers, MRI density, climate). This linear regression yields an equation that is used to compute energy use (also called the dependent variable) based on a series of characteristics that describe the business activities (also called independent variables). This section details the variables used in the statistical analysis for medical offices.

Dependent Variable

The dependent variable is what we try to predict with the regression equation. For the medical office analysis, the dependent variable is energy consumption expressed in source energy use intensity (source EUI). This is equal to the total source energy use of the property divided by the gross floor area. The regressions analyze the key drivers of source EUI – those factors that explain the variation in source energy use per square foot in medical offices.

Independent Variables

The reference survey collects numerous property operating characteristics that were identified as potentially important for medical offices. Based on a review of the available variables in the data, in accordance with the criteria for inclusion in Portfolio Manager,[2] the following variables were analyzed:

- Gross Floor Area
- Number of Floors
- Hours of Operation per Week
- Number of Workers on the Main Shift
- Number of Surgical Operating Beds
- Number of MRI Machines
- Number of Fixed X-Ray Machines
- Number of CAT or CT Scans
- Number of PET Scans
- Number of Linear Accelerators
- Whether or not the Property has a Commercial Kitchen
- Whether or not the Property includes Laboratory Space
- Whether or not the Property includes an Ambulatory Surgical Center
- Whether or not the Property offers Catheterization and Surgical X-ray services
- Heating Degree Days
- Cooling Degree Days
- Percent That Can Be Heated
- Percent That Can Be Cooled

We perform extensive review on all of these operational characteristics. In addition to reviewing each characteristic individually, characteristics are reviewed in combination with each other (e.g., Heating Degree Days multiplied by

[2] For a complete explanation of these criteria, refer to our Technical Reference for the ENERGY STAR Score, at www.energystar.gov/ENERGYSTARScore.

Percent Heated). As part of the analysis, some variables are reformatted to reflect the physical relationships of building components. For example, the number of workers is typically evaluated in a density format. The number of workers *per square foot* (not the gross number of workers) is expected to be correlated with the energy use per square foot. In addition, based on analytical results and residual plots, variables are examined using different transformations (such as the natural logarithm, abbreviated as Ln). The analysis consists of multiple regression formulations. These analyses are structured to find the combination of statistically significant operating characteristics that explain the greatest amount of variance in the dependent variable: source EUI.

The final regression equation includes the following variables:

- Gross Floor Area
- Number of Workers per 1,000 square feet
- Hours of Operation per Week
- Number of Surgical Operating Beds per 1,000 square feet
- Number of MRI Machines per 1,000 square feet
- Heating Degree Days
- Cooling Degree Days

These variables are used together to compute the predicted source EUI for medical offices. The predicted source EUI is the mean EUI for a hypothetical population of buildings that share the same values for each of these variables. That is, the mean energy use for a building that operates just like your building.

Climate Variables

Climate is one characteristic that was examined closely. EPA analyzed the relationship between EUI and both Cooling Degree Days (CDD) and Heating Degree Days (HDD). A combination of methods was used, which included running regression equations with ASHE 2015 data using various forms and combinations of CDD and HDD. Due to the high correlation between CDD and HDD, and the specific cooling and heating needs of medical offices, it was not possible to develop an equitable 1-100 score that included both CDD and HDD using just ASHE 2015 data. Because of this, EPA determined it was necessary to introduce an engineering adjustment for CDD and HDD into the scoring process.

EPA employed an alternative method to account for cooling and heating energy that uses the Department of Energy's commercial reference buildings. These reference buildings use energy modeling to provide complete descriptions of whole building energy use. EPA used data on building size, energy use, and climate information for medical offices across a range of climate zones to identify the relationships between heating energy and HDD, and cooling energy and CDD in the DOE modeled data.

Testing

Finally, we test the regression equation using actual medical offices that have been entered in Portfolio Manager. This provides another set of buildings to examine in addition to the ASHE survey data, to see the average ENERGY STAR scores and distributions, and to assess the impacts and adjustments. This analysis provides a second level of confirmation that the final regression equation produces robust results that are unbiased with respect to the key operational characteristics such as worker density, number of surgical operating beds, number of MRI machines, heating degree days, and cooling degree days.

It is important to reiterate that the final regression equation is based on the nationally representative reference data, not data previously entered into Portfolio Manager.

REGRESSION EQUATION RESULTS

The final regression is a weighted ordinary least squares regression across the filtered data set of 137 observations. The dependent variable is source EUI. Each independent variable is centered relative to the mean value, presented in *Figure 2*. The final equation is presented in *Figure 3*. All variables in the regression equation are significant at the 90% confidence level or better, as shown by the significance levels (a p-level of less than 0.1 indicates 90% confidence).

The regression equation has a coefficient of determination (R^2) value of 0.4401, indicating that this equation explains 44.01% of the variance in source EUI for medical offices. Because the final equation is structured with energy per square foot as the dependent variable, the explanatory power of square foot is not included in the R^2 value, thus this value appears artificially low. Re-computing the R^2 value in units of source energy[3] demonstrates that the equation actually explains 89.21% of the variation of source energy of medical offices. This is an excellent result for a statistically-based energy model.

Detailed information on the ordinary least squares regression approach is available in our Technical Reference for the ENERGY STAR Score, at www.energystar.gov/ENERGYSTARScore.

Figure 2 - Descriptive Statistics for Variables in Final Regression Equation

Variable	Mean	Minimum	Maximum
Source EUI (kBtu/ft^2)	250.9	102.0	568.6
Gross Floor Area	84,175	5,667	351,454
Workers on the Main Shift Per 1,000 ft^2	2.080	0.2611	4.728
Hours of Operation per Week	62.10	39.96	168
Surgical Operating Beds per 1,000 ft^2	0.009331	0	0.09665
MRI Machines pe 1,000 ft^2	0.003156	0	0.03572
Heating Degree Days	3,983	71	9,469
Cooling Degree Days	1,754	16	5,023

Figure 3 - Final Regression Results

Summary	
Dependent Variable	Source Energy Use Intensity (kBtu/ft^2)

[3] The R^2 value in Source Energy is calculated as: 1 – (Residual Variation of Y) / (Total Variation of Y). The residual variation is sum of (Actual Source Energy$_i$ – Predicted Source Energy$_i$)^2 across all observations. The Total variation of Y is the sum of (Actual Source Energy$_i$ – Mean Source Energy)^2 across all observations.

Number of Observations in Analysis		137		
R^2 value		0.4401		
Adjusted R^2 value		0.4188		
F Statistic		20.60		
Significance (p-level)		< 0.0001		
	Unstandardized Coefficients	Standard Error	T value	Significance (p-level)
Constant	250.9	6.634	37.83	< 0.0001
C_Gross Floor Area *(max value of 100,000)*	0.0005471	0.0001211	4.520	< 0.0001
C_Number of Workers per 1000 ft^2	19.51	8.639	2.260	0.0255
C_Weekly Operating Hours	0.5281	0.2986	1.770	0.0794
C_Number of Surgical Operating Beds per 1000 ft^2 *(max value of 0.1)*	1536	354.4	4.330	< 0.0001
C_Number of MRI Machines per 1000 ft^2. *(max value of 0.04)*	3,469	1,222	2.840	0.0053
C_Heating Degree Days	0.004240	0	Infty	< 0.0001
C_Cooling Degree Days	0.01926	0	Infty	< 0.0001

Notes:

- *The regression is a weighted ordinary least squares regression, weighted by the Survey Weights (refer to Survey Weights Section)*
- *The prefix C_ on each variable indicates that it is centered. The centered variable is equal to difference between the actual value and the observed mean. The observed mean values are presented in* ***Figure 2****.*
- *The CDD and HDD coefficients were restricted to the average kBtu/ft^2 for CDD and HDD identified through the analysis of the Department of Energy's Commercial Building Reference Data. The analysis showed that, on average, source heating EUI increases by 0.004240 kBtu/ft^2 for every HDD and source cooling increases by 0.01926 kBtu/ft^2 for every CDD.*
- *The adjustment for Square Footage is capped at a maximum value of 100,000 ft^2, the adjustment for Surgical Operating Beds is capped at 0.1 per 1000 ft^2, and the adjustment for MRI Density is capped at 0.04 per 1000 ft^2.*
- *The ASHE Survey variable was Number of Operating/Surgical Rooms. It will be applied in Portfolio Manager using the existing variable Number of Surgical Operating Beds, which respondents used interchangeably.*

ENERGY STAR SCORE LOOKUP TABLE

The final regression equation (presented in ***Figure 3***) yields a prediction of source EUI based on a building's operating characteristics. Some buildings in the reference data sample use more energy than predicted by the regression equation, while others use less. The *actual* source EUI of each reference data observation is divided by its *predicted* source EUI to calculate an energy efficiency ratio:

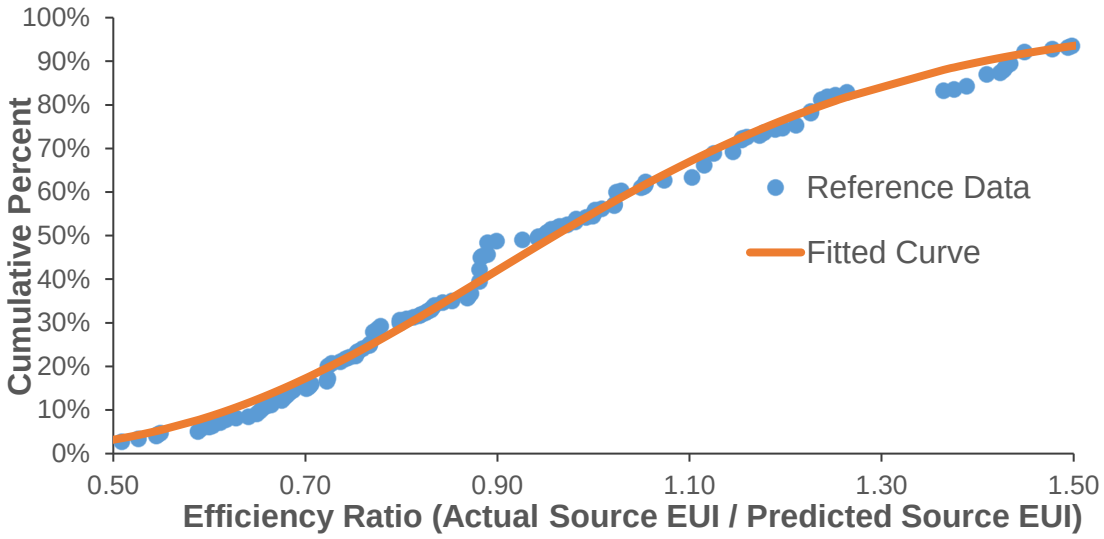
$$Energy\ Efficiency\ Ratio = \frac{Actual\ Source\ EUI}{Predicted\ Source\ EUI}$$

A lower efficiency ratio indicates that a building uses less energy than predicted, and consequently is more efficient. A higher efficiency ratio indicates the opposite.

The efficiency ratios are sorted from smallest to largest and the cumulative percent of the population at each ratio is computed using the individual observation weights from the reference data set. ***Figure 4*** presents a plot of this cumulative distribution. A smooth curve (shown in orange) is fitted to the data using a two parameter gamma distribution. The fit is performed in order to minimize the sum of squared differences between each building's actual

percent rank in the population and each building's percent rank with the gamma solution. The final fit for the gamma curve yielded a shape parameter (alpha) of 10.18 and a scale parameter (beta) of 0.09749. For this fit, the sum of the squared error is 0.06041.

Figure 4 - Distribution for Medical Office Buildings



The final gamma shape and scale parameters are used to calculate the efficiency ratio at each percentile (1 to 100) along the curve. For example, the ratio on the gamma curve at 1% corresponds to a score of 99; only 1% of the population has a ratio this small or smaller. The ratio on the gamma curve at the value of 25% will correspond to the ratio for a score of 75; only 25% of the population has ratios this small or smaller. The complete score lookup table is presented in *Figure 5*.

Figure 5 – ENERGY STAR Score Lookup Table for Medical Offices

ENERGY STAR Score	Cumulative Percent	Energy Efficiency Ratio > =	Energy Efficiency Ratio <	ENERGY STAR Score	Cumulative Percent	Energy Efficiency Ratio >=	Energy Efficiency Ratio <
100	0%	0.0000	0.4136	50	50%	0.9598	0.9675
99	1%	0.4136	0.4619	49	51%	0.9675	0.9752
98	2%	0.4619	0.4945	48	52%	0.9752	0.9830
97	3%	0.4945	0.5201	47	53%	0.9830	0.9908
96	4%	0.5201	0.5417	46	54%	0.9908	0.9987
95	5%	0.5417	0.5604	45	55%	0.9987	1.0066
94	6%	0.5604	0.5773	44	56%	1.0066	1.0146
93	7%	0.5773	0.5927	43	57%	1.0146	1.0227
92	8%	0.5927	0.6069	42	58%	1.0227	1.0309
91	9%	0.6069	0.6202	41	59%	1.0309	1.0392
90	10%	0.6202	0.6328	40	60%	1.0392	1.0476
89	11%	0.6328	0.6447	39	61%	1.0476	1.0561
88	12%	0.6447	0.6561	38	62%	1.0561	1.0646
87	13%	0.6561	0.6670	37	63%	1.0646	1.0734
86	14%	0.6670	0.6775	36	64%	1.0734	1.0822
85	15%	0.6775	0.6877	35	65%	1.0822	1.0912
84	16%	0.6877	0.6975	34	66%	1.0912	1.1004
83	17%	0.6975	0.7071	33	67%	1.1004	1.1097
82	18%	0.7071	0.7164	32	68%	1.1097	1.1191
81	19%	0.7164	0.7255	31	69%	1.1191	1.1288
80	20%	0.7255	0.7345	30	70%	1.1288	1.1387
79	21%	0.7345	0.7432	29	71%	1.1387	1.1488
78	22%	0.7432	0.7518	28	72%	1.1488	1.1591
77	23%	0.7518	0.7602	27	73%	1.1591	1.1697
76	24%	0.7602	0.7686	26	74%	1.1697	1.1806
75	25%	0.7686	0.7768	25	75%	1.1806	1.1917
74	26%	0.7768	0.7849	24	76%	1.1917	1.2032
73	27%	0.7849	0.7929	23	77%	1.2032	1.2151
72	28%	0.7929	0.8008	22	78%	1.2151	1.2273
71	29%	0.8008	0.8087	21	79%	1.2273	1.2400
70	30%	0.8087	0.8164	20	80%	1.2400	1.2531
69	31%	0.8164	0.8242	19	81%	1.2531	1.2668
68	32%	0.8242	0.8318	18	82%	1.2668	1.2811
67	33%	0.8318	0.8395	17	83%	1.2811	1.2960
66	34%	0.8395	0.8471	16	84%	1.2960	1.3117
65	35%	0.8471	0.8546	15	85%	1.3117	1.3282
64	36%	0.8546	0.8621	14	86%	1.3282	1.3457
63	37%	0.8621	0.8696	13	87%	1.3457	1.3643
62	38%	0.8696	0.8771	12	88%	1.3643	1.3842
61	39%	0.8771	0.8846	11	89%	1.3842	1.4057
60	40%	0.8846	0.8921	10	90%	1.4057	1.4290
59	41%	0.8921	0.8996	9	91%	1.4290	1.4547
58	42%	0.8996	0.9070	8	92%	1.4547	1.4832
57	43%	0.9070	0.9145	7	93%	1.4832	1.5155
56	44%	0.9145	0.9220	6	94%	1.5155	1.5528
55	45%	0.9220	0.9295	5	95%	1.5528	1.5975
54	46%	0.9295	0.9371	4	96%	1.5975	1.6535
53	47%	0.9371	0.9446	3	97%	1.6535	1.7299
52	48%	0.9446	0.9522	2	98%	1.7299	1.8547
51	49%	0.9522	0.9598	1	99%	1.8547	> 1.8547

EXAMPLE CALCULATION

As detailed in our Technical Reference for the ENERGY STAR Score, at www.energystar.gov/ENERGYSTARScore, there are five steps to compute a score. The following is a specific example for the score for medical offices:

1 User enters building data into Portfolio Manager

- 12 months of energy use information for all energy types (annual values, entered in monthly meter entries)
- Physical building information (size, location, etc.) and use details describing building activity (number of workers, etc.)

Energy Data	Value
Electricity	703,400 kWh
Natural gas	42,000 therms

Property Use Details	Value
Gross floor area (ft^2)	50,000
Workers on the Main Shift	100
Number of Surgical Operating Beds	1
Number of MRI Machines	1
CDD (provided by Portfolio Manager, based on ZIP code)	1,074
HDD (provided by Portfolio Manager, based on ZIP code)	6,126

2 Portfolio Manager computes the actual source EUI

- Total energy consumption for each fuel is converted from billing units into site energy and source energy.
- Source energy values are added across all fuel types.
- Source energy is divided by gross floor area to determine actual source EUI.

Computing Actual Source EUI

Fuel	Billing Units	Site kBtu Multiplier	Site kBtu	Source kBtu Multiplier	Source kBtu
Electricity	703,400 kWh	3.412	2,400,000	2.80	6,720,000
Natural gas	42,000 therms	100	4,200,000	1.05	4,410,000
				Total Source Energy (kBtu)	11,130,000
				Actual Source EUI (kBtu/ft^2)	222.6

3 Portfolio Manager computes the predicted source EUI

- Using the property use details from Step 1, Portfolio Manager computes each building variable value in the regression equation (determining the natural log or density or applying any minimum or maximum values used in the regression model, as necessary).
- The centering values are subtracted to compute the centered variable for each operating parameter.
- The centered variables are multiplied by the coefficients from the regression equation to obtain a predicted source EUI.

Computing Predicted Source EUI

Variable	Actual Building Value	Reference Centering Value	Building Centered Variable	Coefficient	Coefficient * Centered Variable
Constant	-	-	-	250.9	250.9
Gross Floor Area *(max value of 100,000)*	50,000	84,175	-34,175	0.0005471	-18.70
Number of MRI Machines per 1,000 ft^2	0.02000	0.003156	0.01684	3,469	58.43
Number of Surgical Operating Beds per 1,000 ft^2	0.02000	0.009331	0.01067	1,536	16.39
Number of Workers per 1,000 ft^2	2.000	2.080	-0.08000	19.51	-1.561
Weekly Operating Hours	55	62.10	-7.100	0.5281	-3.748
Heating Degree Days	6,126	3,983	2,143	0.004240	9.086
Cooling Degree Days	1,074	1,754	-680	0.01926	-13.10
				Predicted Source EUI (kBtu/ft^2)	297.7

4 Portfolio Manager computes the energy efficiency ratio

- The energy efficiency ratio equals the actual source EUI (Step 2) divided by predicted source EUI (Step 3)
- Energy Efficiency Ratio = 222.6 / 297.7 = 0.7477

5 Portfolio Manager uses the efficiency ratio to assign a score via a lookup table

- The energy efficiency ratio from Step 4 is used to identify the score from the lookup table
- An energy efficiency ratio of 0.7477 is greater than or equal to 0.7432 and less than 0.7518.
- *The ENERGY STAR score is 78*